“Smitten by Science”

Under Secretary of Commerce for the Oceans and Atmosphere
and NOAA Administrator
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As delivered

Thank you, Senator [Rockefeller]. It’s an honor and privilege to be here today.

If you don’t know it already, Senator Rockefeller has been a great champion of science in this country. And the National Youth Science Foundation is just one of the many ways he shows his support.

I confess that I, too, am an advocate for science. And, a scientist as well – specifically, a marine ecologist. Today I’m going to tell you a little bit about how I was bitten by the science bug, how a Colorado girl became a marine biologist, why science is important to everyone, and how we turn science into solutions for the planet.

How I was bitten by the science bug

I liked science in high school. But, truth be told, I liked lots of things. A week-long summer science camp after my junior year exposed me to a broader range of science than I’d been exposed to in high school and it gave me great opportunities to see that I was good at it as well, and to connect with other students who shared my interests..

Although I continued to like most subjects in college, I was particularly intrigued with biology. I had the great fortune to attend Colorado College which offered great professors and ample opportunity for spectacular field trips. I had always spent a lot of time in the Rocky Mountains, hiking, fishing, camping and being intrigued by patterns in nature.

How I became a marine biologist

Then in the summer between my junior and senior years, I had a life-altering experience. I was given the gift of a summer at the Marine Biological Laboratory in Woods Hole, Massachusetts. And when I say “gift”, I don’t mean that I didn’t work hard for it. I had to apply and get accepted into the program – probably not very different from what you went through to get in the program in West Virginia. But it was a gift in the sense that it opened my eyes to marine biology and the joys of research. It became the portal to my future.

The Marine Biological Laboratory is a famous place for marine biology. It has the aura of greatness, complete with a plethora of Nobel Laureates doing research there or coming to give lectures, all set in a relaxed, sea-side community right on Cape Cod. Its history dates back to 1888. Its unofficial motto is a quote from Louis Agassiz, “Study Nature, Not Books” that, ironically, is inscribed above the entrance to the library! The intellectual atmosphere was intoxicating; there were passionate discussions and arguments about biological patterns and processes. Almost daily, I’d be inspired by a new idea. I was struck by something that Albert Szent-Gyorgyi said in one of his lectures: 'A genius is someone who sees what others have seen but thinks what no one else has thought.'

But amidst the intellectual excitement, it was the critters that really captured my imagination. I was taking a course in invertebrate zoology – the myriad creatures without backbones that populate the planet, but especially the oceans. Guided by the systematic approach of the course and the opportunity for exploration and field trips, I discovered an entirely new world that I had no idea existed. It was endlessly fascinating and intriguing. Seastars, squid, sea urchins, crabs, sponges, barnacles – all sorts of fascinating and exotic critters. I discovered I was good at detecting patterns, at distinguishing something different from the background. I learned that thinking about things in a different way from everyone else is often valuable in science.

And Woods Hole is where I fell in love with doing research. I spent the second half of the summer conducting my own research project. I discovered I loved problem solving, designing experiments, learning how to analyze and make sense out of data. I worked extremely hard but I loved every single minute.

That whole summer was magical for me. As 20-year-old from Colorado, I decided then and there that following my senior year, I would go to grad school and study marine biology. I did just that, and I've never looked back. I've loved every minute of it.

Grad school turned out to be at the University of Washington and at Harvard. I continued to be exposed to different ways of thinking about problems. For example, I was exposed to the pioneering approaches of experimental field ecology. At the time, experiments were common in physiology or other laboratory disciplines, but unheard of in field work. I had the great fortune to work with scientists who developed new techniques for doing experiments in the field – transplanting species from low on the seashore to higher up in the intertidal zone, or caging out predators -- to test hypotheses and figure out what was causing a particular pattern. Distinguishing causation from correlation turned out to be key to advancing understanding.

And so my research was experimental. I discovered new patterns and new insights into causes of patterns in nature. For example, ecologists were and are interested in discovering why some places have large number of species and others have few. Most ideas about causes of patterns had focused on differences in physical factors such as temperature.

I noticed that different tide pools on rocky seashores in Massachusetts had different numbers of seaweeds despite having similar physical characteristics.

In looking more closely, I noticed that there were also different numbers of snails in the pools, snails that eat seaweeds. Here is the pattern I observed. See if you come up with the same hypothesis that I did:

- Ponds with few snails had a low diversity of seaweeds and the seaweeds were primarily green algae.
- Ponds with intermediate number of snails had the highest diversity of seaweeds, of virtually all kinds.
- Ponds with the largest number of snails had low diversity, but mostly red algae. Put differently, the pools with the lowest diversity of seaweeds either had very few snails or a very large number of snails.

- Pools with the highest diversity had intermediate numbers of snails.

I hypothesized that some seaweeds were more palatable to snails than other seaweeds - that is, that snails would preferentially eat some seaweeds. I tested this in the laboratory by offering snails choices of different seaweeds and found that indeed they did consistently choose certain seaweeds over others.

I then hypothesized that the seaweeds that were more tasty were also the better competitors for space. In other words, if snails were rare, the tasty seaweeds would outcompete other seaweeds, resulting in low diversity. If snails were super abundant, they would eat everything palatable, leaving only a few species of seaweeds. And an intermediate number of snails would keep the competitive dominants in check, allowing the largest number of species of seaweeds to coexist. Nice hypotheses, consistent with the information, but was it true? How would you test these ideas?

To test these ideas, I manipulated the abundance of snails in a series of similar sized pools at similar tidal levels. I removed snails from some pools, added them to others. Lo, and behold, I could change the diversity and kind of seaweeds simply by changing the abundance of snails. This was a simple and early demonstration of the important influence of biological factors in determining patterns of distribution and abundance and diversity. We now understand that biological factors such as competition and herbivory or predation, interact with physical factors to determine who lives where. And the paper that I published from these experiments became a 'Science Citation Classic' meaning that it has been cited by other scientists a lot.

This story makes three important points.

- One – that we can't simply make assumptions in science without testing their validity. For years, tide pool ecologists assumed that the physical environment – tidal height, temperature, salinity, etc. - determined the distribution of seaweeds in a tide pool.
- Two – You have to be curious to be a scientist. If I hadn't been curious, I wouldn't have looked for alternative explanations. Curiosity doesn't always kill the cat.
- Three – You have to be bold. You can't be afraid to ask if something is valid. Is it true? And you brace yourself to do some rigorous thinking about the evidence...because in science, we make claims based on evidence. Without proper and adequate evidence, a claim remains open to question.

Why science is important to everyone

At NOAA, we do ecological research as well as other kinds of science. NOAA stands for the National Oceanic and Atmospheric Administration.

We produce daily weather forecasts and severe storm warnings. We monitor climate. We manage fisheries, restore coastlines, and support marine commerce. NOAA's products and services support the economy and protect lives and property. NOAA's dedicated scientists use cutting-edge research and high-tech instrumentation to provide citizens, planners, emergency managers, businesses and others with reliable information they need when they need it.

Our mission is **science, service, and stewardship**. Our job is to understand and predict changes in climate, weather, oceans, and coasts, to share that knowledge and information with others, and to conserve and manage coastal and marine ecosystems and resources.

Science at NOAA builds the knowledge we need to make environmental predictions. Science guides us toward the best tools for protecting our oceans, our coasts, and Great Lakes, and the people who live there. And these tools are the solutions to many of the very daunting challenges we face on our planet today. They are our hope for ending the overfishing that has depleted fish populations in the ocean. They are our hope for maintaining the biodiversity the planet needs to maintain healthy ocean ecosystems. They are the hope for helping people all over the world prepare for drought, floods, hurricanes, tornadoes, wildfires, and other extreme weather events. All of that can come out of science.

Now, I'm going to show you one small part of the science we do at NOAA. And I'm also going to tell you how that science became a solution to a practical problem. I think you'll see some similarities between the science we do at NOAA, and the science from my grad school days.

You see on the poster here and on your handouts a picture of a marine pteropod, a swimming sea snail about the size of a pea. Some call it a sea butterfly. It's easy to see why:they fly delicately and gracefully through the water.

Pteropods live in the upper depths of oceans all over the world. They live in cold, fragile Arctic waters, in temperate zones, and warm, tropical seas.

Pteropods are a major food source for many species of fish and other marine species.

Like other snails, the animal lives inside its shell. The shell is made of calcium carbonate, not unlike the shells of oysters, except that in pteropods, the shell is thin.

Scientists recently discovered that the chemistry of the ocean is changing in ways that affect pteropods. Specifically, the burning of fossil fuels has caused an increase in carbon dioxide levels in the atmosphere. This carbon dioxide, or CO_2, doesn't just stay in the atmosphere – roughly 30 percent of it is absorbed by the ocean. When oceans absorb CO_2, they become more acidic. This is the process called ocean acidification. We know based on direct measurements that oceans are now about 30% more acidic than they were at the beginning of the Industrial Revolution. They have been absorbing more and more CO_2 and thus becoming more acidic.

What are the consequences of these changes in ocean chemistry? And what is likely to happen in the future?

Using ocean models, we can make projections of changes in ocean acidity, or ocean pH over time. And we can simulate future likely conditions in the laboratory. The images you see on the poster and handouts describe what happened to pteropod shells when they were in ocean water that is similar to what scientists expect to occur by the end of this century. Because the ocean water is more acidic, the shell dissolves away.

Scientists expect that most plants and animals in the ocean that have external shells or skeletons made of calcium carbonate will be affected by ocean acidification. This includes oysters, clams, corals, lobsters, crabs, sea stars, sea urchins and many kinds of microscopic plants in the ocean.

Some call ocean acidification 'osteoporosis of the sea'.

This is clearly a potentially serious problem. NOAA and other scientists are busily gaining more information about rates of change, how these changes impact different kinds of species, how changes in some species like pteropods will affect other species such as salmon, and what in addition to reducing release of CO_2 into the atmosphere might be done to help with this problem.

How Science Turns into a Solution

Now I want to show you how science is transformed into a solution.

Now we're going to jump to an oyster hatchery in Oregon to see how knowing the science of ocean acidification helps us.

About six years ago, some oyster hatcheries – commercial oyster farms – in the Pacific Northwest began to see an alarming decline in oyster production. Their oyster larvae were dying and they didn't know why.

By 2008, the oyster harvest at Whiskey Creek, a major Oregon supplier to the majority of West Coast oyster farmers, plummeted 80 percent. At about the same time, scientists were documenting acidified seawater along the West Coast.

Something had to be done. Oyster production accounts for more than $84 million of the West Coast shellfish industry, which supports more than 3,000 jobs. The oyster hatchery owners needed to know why their oyster shells were dissolving in water.

Scientists in Oregon who were part of an international team studying ocean acidification thought that ocean acidification might be the culprit. First, you have to understand how the hatchery works. Water from the local bay is used to grow oyster larvae at the hatchery. During warmer months, the water is more acidic and oyster larvae were dying. Since ocean acidification is a relatively recent event, hatchery owners had only seen this lethal effect in recent years.

Once scientists determined that ocean acidification was a probable cause for their production problems, hatchery owners knew to 'neutralize' water during times when water was more acidic. Today, real-time data from a network of offshore buoys that can detect harmful seawater acts as an early warning system for shellfish hatcheries. The buoys signal the approach of cold, acidified seawater one to two days before it arrives in the sensitive coastal waters where larvae are cultivated. The data help hatchery managers schedule production when water quality is good and avoid wasting valuable energy and other resources when water quality is poor.

Armed with better information about the ocean conditions that oysters can and cannot tolerate, Taylor Shellfish Farms was able to adapt its operations accordingly. Last year was its best year since 1989. Whiskey Creek also enjoyed substantial increases in its oyster harvest. In 2008, productivity for Whiskey Creek was at just 20 percent of its normal level; by 2010, it had risen to 70 percent.

Ocean acidification is an emerging global problem, particularly because shelled organisms like oysters and pteropods are key species in the marine food web. As human food and a source of income, shellfish also sustain many millions of people worldwide. Keeping an eye on changing ocean conditions through buoy networks and other sophisticated observing systems is paramount.

Ocean acidification is one of many changes we face in the world's oceans today. In the United States, President Obama signed the first National Ocean Policy calling for actions that would ensure healthy oceans.

Science is about documenting what happening. We do this by observing in many ways: satellites in space, planes in the air, radar on the ground, buoys in the water, and gliders under the sea. Science is using those observations and basic scientific knowledge to build and constantly improve our understanding of what's happening and how it's happening. These are our models of how the Earth system works. And science can point us to solutions

I know that you're serious about science. Come take a look at NOAA. We have an enormously wide range of career opportunities to explore. Whether you're interested in weather, oceans, biology, ecology, physics, atmospheric science, microbiology, chemistry, or being an ocean explorer, NOAA could be a good fit for you.

We can't do the science or develop the solutions without the people to do the science. I like to say that at NOAA people are our greatest asset.

Thank you.